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BAE SYSTEMS

GENERAL DYNAMICS
Robotic Systems

Survivability on the ART Robotics Vehicle

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Outline

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- ART Program
- Sensor Configuration
- Anti-Tamper
- Intent Analysis (Visual and IDS system)
- Countermeasures (Tactical Behaviors)

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Report Documentation Page

Form Approved
OMB No. 0704-0188

1. REPORT DATE	2. REPORT TYPE	3. DATES COVERED
16 MAR 2006	**Briefing Charts**	**27-12-2005 to 03-03-2006**

4. TITLE AND SUBTITLE	5a. CONTRACT NUMBER
Survivability on the ART Robotics Vehicle	5b. GRANT NUMBER
	5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)	5d. PROJECT NUMBER
John Stean; Michael Del Rose	5e. TASK NUMBER
	5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)	8. PERFORMING ORGANIZATION REPORT NUMBER
General Dynamics,Sterling Heights Complex,38500 Mound Road,Sterling Heights,Mi, 48310-320	**; #15636**
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)	10. SPONSOR/MONITOR'S ACRONYM(S)
U.S. Army TARDEC, 6501 East Eleven Mile Rd, Warren, Mi, 48397-5000	**TARDEC**
	11. SPONSOR/MONITOR'S REPORT NUMBER(S)
	#15636

12. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution unlimited

13. SUPPLEMENTARY NOTES
Presented at Ground Vehicle System Survivability (GVSS)

14. ABSTRACT
Briefing Charts

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			
unclassified	**unclassified**	**unclassified**	**Public Release**	**9**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

Armed Robotic Technology (ART) Platform

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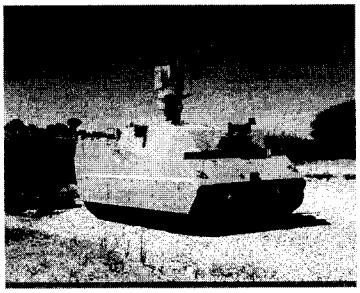

Schedule

MILESTONE (FY)	05	06	07	08	09
• Develop ARV Technologies					
• Develop UGV Mobility M&S Suite					
• Analyze UGV Vulnerabilities and develop countermeasures					
• System Integration and Test					
• Conduct Warfighter Experiments and Evaluations					

Purpose:

Advance the state of the art in unmanned platform technologies to achieve FCS ORD Objective capabilities of UGV systems.

Product:

- ***Enhanced Semi-Autonomous Mobility Suite***
- ***Integrated Tactical/Mission Behavior System***
- ***Increased Platform Maneuverability***
- ***Survivability Technology/Devices/Payload***

Payoff:

- ***Reduced soldier burden/interaction***
- ***Improved semi-autonomous operation in adverse weather and urban/complex terrain.***
- ***Tactical behavior incorporated into semi-autonomous maneuver.***
- ***Increased mobility over rough terrain.***
- ***Increased soldier survivability using unmanned systems.***
- ***Reduced risk to FCS ARV and MULE***

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ART Sensors

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- Intrusion Detection System (IDS) Radar
  - FM/CW
  - FOR:100m X 360deg H X ±30deg V
- RSTA
  - Visible, NIR, IR, LRF
  - FOR: 360deg H X 30deg V
  - ATD/AiTR
- Autonomous Mobility System (AMS)
  - Visible, NIR, IR, LADAR
  - FOR: 100m X 360deg H

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ART Sensor Configuration

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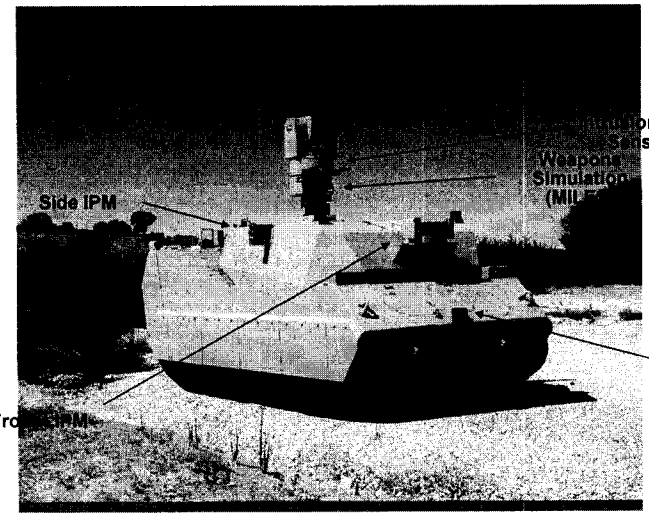

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ART Sensor Coverage

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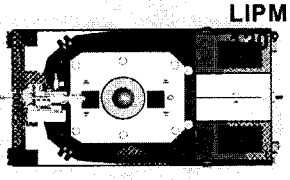
IDS RADAR 360°

IPM 120°

LIPM 120°

LIPM

MMW Radar 15°



LADAR 180°

IPM 120°

LADAR 180°

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Anti-Tamper

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- **What is "Anti-tamper" protection?**

  For ART: Anti-tamper refers to a system that determines the threat of an approaching person and actions to avoid the threat. It does NOT imply the ability of systems to be rendered useless (as traditionally defined).

- **Anti-tamper for the ART platform uses Visual Intent Analysis and IDS Radar.**

Intent Analysis - Visual System

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- Visual Intent Analysis framework
  - Uses pedestrian detection/tracking to determine and track people as differentiated from other objects.
  - Classifies the intent of the people based on movements.
  - Hostile intentions trigger countermeasures (tactical behaviors).

Visual Intent Analysis - Pedestrian Detection/Tracking

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- Uses stereo infrared and color cameras to identify people and track them using disparity mappings, color blob analysis, and body positions.
- Tracks people through occlusions.

Visual Intent Analysis - Pedestrian Detection/Tracking

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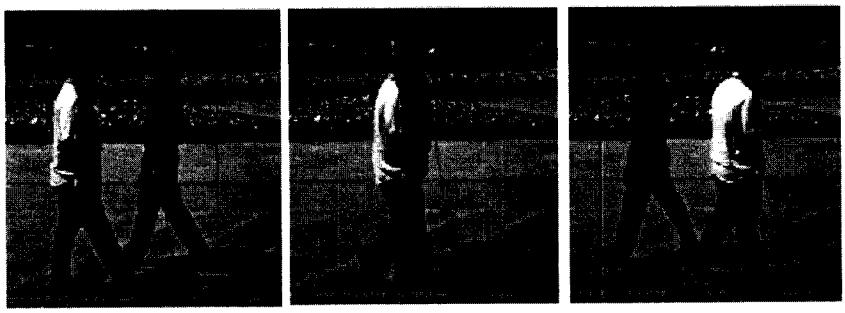

Visual Intent Analysis - Determining Intent Visually

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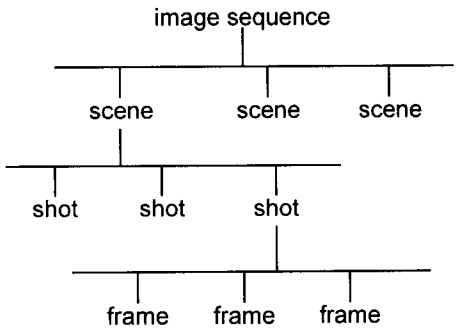
Video data hierarchy



Scenes: Global content and Intent.

Shot: Objects and object relations, motion, and locations of objects

Frames: Low level – color, texture, and shape.

Visual Intent Analysis - Identify the Scene

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- Identifying the scenes (and shots) requires a well defined feature space.
- Usually requires color and motion.
- Basically, we are trying to find major changes in the image sequence.

Visual Intent Analysis - Identify the Scene

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Modeling Scene into Simple Verbs

- From identifying and tracking the objects in the scene, we can determine their actions and their relationship with each other.
- Examples of simple verbs are: pickup, putdown, move, touch, etc.

Visual Intent Analysis - Identify Intent of the Scene

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- Once each object is modeled, thus the scene is modeled, we can identify the intent based on prior information.
- Example: The intent of a person (O1) picking up an object (O2) and moving it to another location would be observed as: *O1 moves. O1 touches O2. 01 moves. O2 moves. O1 un-touches 02. O1 exits.*

Intent Analysis -IDS Radar

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- Determine intruder motion
  - Range, range rate, bearing
  - Crawling, walking, running
  - Intruder tracks
- Used by the AMS to identify potential threats
- Future UGV systems may use this in conjunction with the FCS Common Operating Picture (COP).

Countermeasures (Tactical Behaviors)

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- Layered Response
  - Dependent upon threat level as determined by intent analysis
- Responses
  - Aural warning/High-intensity spotlight
  - Start/Rev engine
  - Move away
  - Move toward
  - Point gun
  - Shoot (MILES)

Conclusion

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- ART Survivability utilizes several key sensors to protect itself from hostile intentions by people – called Anti-tamper.
- Anti-tamper uses both visual (Visual Intent Analysis) and radar (IDS Radar) to determine intentions of possible hostiles.
- Anti-tamper will be demonstrated in two user experiments (Jun-07, and Feb-09).

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Questions ???